ZOOLOGIA 34: e14882
ISSN 1984-4689 (online)
zoologia.pensoft.net

SHORT COMMUNICATION

# Temporal differences in breeding site use between tits and mice

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*http://zoobank.org/EDA3E6B1-D15B-451A-87D2-F912245A065C*

ABSTRACT. Describing the interactions among cavity breeders is key to understanding their breeding ecology. In this study the temporal difference in cavity use between the great tit, *Parus major* (Linnaeus, 1758) and the small Japanese field mice, *Apodemus argenteus* (Temminck, 1845) is investigated, as a first step for clarifying the interaction between bird and mammal cavity breeders. Forty-seven nest boxes were installed on tree trunks in two urban forests of Hokkaido Island, Japan, and the breeding nests of tits and mice were found in 34 and 11 boxes, respectively. The tits used the nest boxes throughout the breeding season, from May to July. In contrast, mice breeding nests were found in the last half of the breeding season, from July to October. Our results showed that field mice rarely used boxes during the tits' breeding season. This study provides important information, such as temporal differences in breeding site use between tits and mice.

KEY WORDS. Bird-mammal interaction, breeding ecology, competition, reproduction strategy, tree cavities.

Tree cavities are used as breeding and nesting sites by numerous wildlife species (Martin and Eadie 1999, Martin et al. 2004). There are several types of interactions among cavity users. Understanding these interactions is crucial for accurately understanding the ecology of cavity breeders (e.g., Minot and Perrins 1986, Newton 1994), since cavity users often segregate spatially and/or temporally in the use of cavities, thus avoiding competition. For example, the small Japanese field mouse, *Apodemus argenteus* (Temminck, 1845), nests in cavities near the ground, to avoid competition with the Siberian flying squirrel, *Pteromys volans* (Suzuki and Yanagawa 2012, Suzuki et al. 2014). Also, the pied flycatcher *Ficedula hypoleuca* (Pallas, 1764) and the great tit *Parus major* (Linnaeus, 1758) have different breading seasons and that increases the breeding success of the flycatcher (Slagsvold 1978).

Intra-class interactions, such as mammal-mammal (Shafique et al. 2009, Nakamura-Kojo et al. 2016) or bird-bird (Minot and Perrins 1986, Newton 1994) have been more thoroughly investigated. Inter-class -bird-mammal interactions, in contrast, are likely to go unrecognised and have been systematically ignored by scientists, despite the fact that they are important to understand cavity-breeding ecology (Czeszczewik et al. 2008). As a first step to study these interactions, it is important to try to ascertain the different uses of breeding cavities (Suzuki and Yanagawa 2012) and to clarify the interactions among cavity users (Suzuki et al. 2014). In this contribution, we surveyed the breeding sites of great tits and small Japanese field mice, some of the most abundant, similarly sized (10 to 20 g) cavity breeders in Japanese forests, to provide information on the temporal and spatial differences in how they use breeding cavities.

To survey the breeding site uses by the two species, we installed 47 handmade, wooden nest boxes within a total of approximately 9.8 ha bordering two urban forests (42°51' to 42°53'N, 143°09' to 143°11'E) in the Tokachi area of eastern Hokkaido, Japan, on 8 and 9 June 2011. Details on the environments of survey forests are shown in Suzuki et al. (2016). On Hokkaido Island, the breeding seasons of the two species largely overlap. The main breeding season of great tits is from May to July, and they rarely breed in August (Yuta and Koizumi 2012). In mice, reproductively active females are found from April to September (Fujimaki 1969).

Other cavity nesters in this area are the Eurasian nuthatch, *Sitta europaea* (Linnaeus, 1758), and the Siberian flying squirrel, *Pteromys volans* (Linnaeus, 1758) (Suzuki et al. 2016). We are confident that, during the observation period, the nest boxes

were not used by either species. The nests of the nuthatch are easily identifiable by the size of their entrance, which is reduced by smeared pellets of dirt, and flying squirrels are too big for the, small circular entrance of the nest box (diameter 2.5 cm) (Suzuki et al. 2014). The boxes were uniform in size (24 cm high × 8 cm wide × 18 cm deep), walls 2.5 cm thick, and were installed at a distance of more than 20 m apart in the forests. This distance was adopted because the distance among the naturally occurring breeding nests of the mice is approximately 20 m (Setoguchi 1981). Nest boxes were installed from 0.7 m to 2.8 m from the ground. By doing this, we aimed to ascertain the spatial differences in breeding sites, since cavity height plays an important role in predator avoidance, and cavity-nesting animals often use different heights to avoid competition (Suzuki and Yanagawa 2012, Suzuki et al. 2014).

We checked the boxes monthly from July to November 2011. From December 2011 to February 2012, we were unable to check them due to heavy snow cover. We checked the boxes again in early March 2012, at which time the nest materials of the previous year were removed from all nest boxes to prevent old nest materials in the nest boxes from being used in the second year. At that time, neither species had started breeding in any of the nest boxes. From May to October 2012, the boxes were checked twice a month. When adult great tits, eggs, and/or chicks were found in a nest box, we recorded the nest as a tits breeding site. When small Japanese field mice and/or neonates were found in the boxes, we recorded the nest as a mice breeding site.

We treated the first year as a habituation period, since nest utilisation by vertebrates usually starts many months after installation of the boxes (Ando 2005). Therefore, we used data from the second survey year, from May to October 2012, for the two analyses described below. To clarify temporal differences in cavity use between great tits and small Japanese field mice, we counted the number of nest boxes used for breeding per nest box check and evaluated the correlation of nest box uses between tits and mice using Spearman's rank correlation. In addition, we constructed a logistic regression model to determine the spatial difference between the breeding sites of tits and mice. In this model, we treated the presence of tits or mice as a categorical dependent variable. Nest box height was treated as a continuous independent variable. The effect of the independent variable was evaluated using a $\chi^2$ test. These analyses were run in the statistical software R ver. 3.2.4 (R Core Team 2016).

From May to October 2012, tits and mice bred in 34 and 11 nest boxes, respectively. While it appears that the proportion of boxes used by mice was relatively low, it did not differ much from results obtained by previous surveys using nest boxes (14/87 nest boxes, from July to October 2010) and natural cavities (21/136 natural cavities, from May to October 2009 and from May to October 2010) (Suzuki and Yanagawa 2012) in the area. The great tit used the nest boxes from early May to mid-July, and there was a mono-modal peak of use around mid-May to early June (Fig. 1). After this, the number of tits breeding in the boxes rapidly decreased, and no breeding was recorded in early August. In contrast, small Japanese field mice used the boxes from early July,

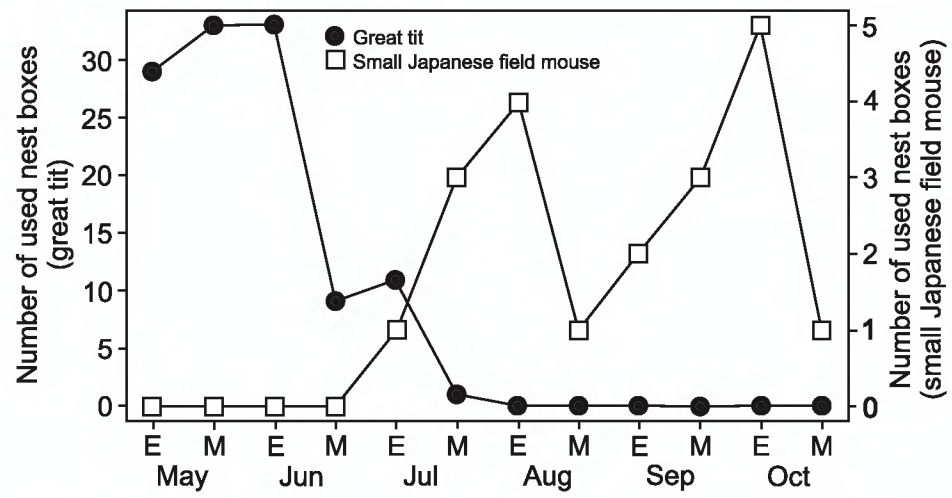


Figure 1. Number of nest boxes used by *Parus major* and *Apodemus argenteus* in 2012. On the x-axis, E indicates "Early" and M indicates "Middle".

when the breeding of the tits had almost ceased (Fig. 1). Bimodal peaks of mice breeding were recorded around early August and early October. The mean heights of the boxes used by the great tits and mice were 1.47 ± 0.58 (SD) m and 1.45 ± 0.62 m, respectively.

There was little overlap between the breeding periods of tits and mice (Fig. 1, $z = -2.59$, $p = 0.01$) in the nest boxes. In other words, a negative correlation was shown in nest box use between tits and mice. The height of the nest boxes used by the two species was quite similar (Fig. 2, $\chi^2 = 0.02$, $p = 0.88$). Although the tits used the nest boxes throughout their breeding season (Fig. 1), mainly from May to July (Yuta and Koizumi 2012), the mice only used the boxes on the last half (Fig. 1) of their main breeding season, April to September (Fujimaki 1969). This is in contrast to a report that mice use nest boxes throughout their breeding season on the Kyushu Island (Sakata et al. 2009, 2010), where there was no overlap between the breeding seasons of mice (Yoshida 1972) and tits (Seki 2000). Notably, the varied tit, *Parus varius* (Temminck & Schlegel, 1845), occur as a third species of cavity breeders on that Island, although the effects of these tits on mice breeding may be negligible, in view of their differing breeding seasons (Ueta et al. 2007) that do not overlap (Yoshida 1972).

To avoid competition, sympatric cavity nesters often breed in the cavities in different seasons (Slagsvold 1978). Therefore, it is possible that mice avoid using boxes when breeding tits occupy them, to decrease competition, (Fig. 1). The mice are able to breed underground, as well as in cavities (Setoguchi 1981). It is possible that, in this study area, mice breed underground from May to early July. Additional surveys are needed to examine the seasonal changes in the breeding sites of these mice.

## ACKNOWLEDGMENTS

We thank T. Oshida and M.B. Takada for their constructive comments on this study. We also thank A. Kimoto for comments on statistical analyses. We acknowledge the invaluable comments of two anonymous reviewers and the editor on an earlier version of this manuscript.

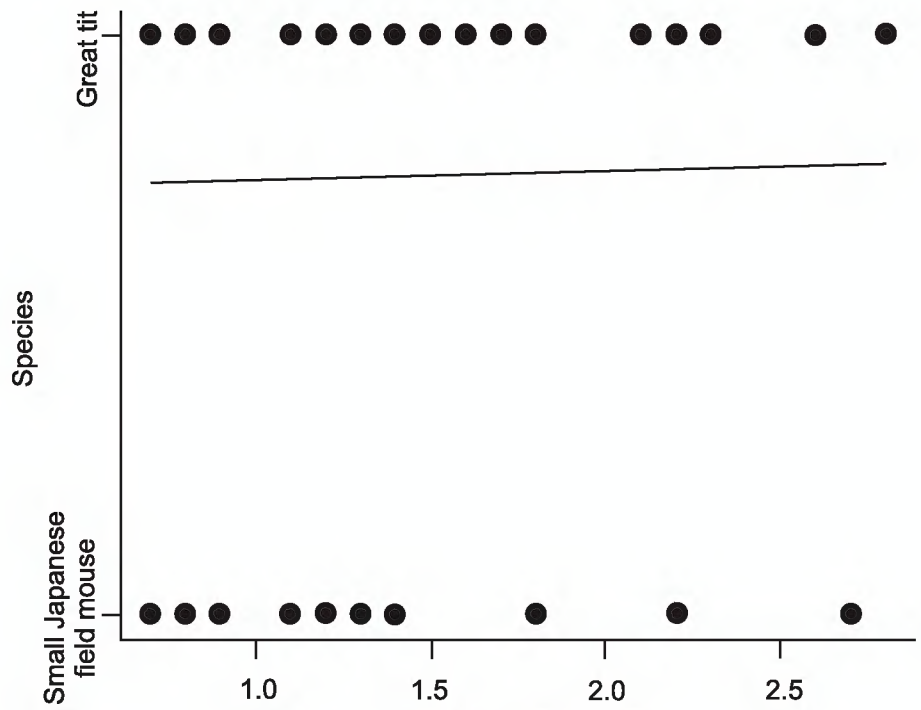


Figure 2. Plots of the height of nest boxes used by *Parus major* and *Apodemus argenteus* with a logistic regression curve.

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Submitted: 19 July 2016
Received in revised form: 17 October 2016
Accepted: 10 March 2017
Editorial responsibility: Jorge Salazar-Bravo

**Author Contributions:** KKS and HY designed the experiment; KKS, YT, YY, TS, and RGF conducted field works; KKS analyzed the data; all authors contributed to write and review the paper.
**Competing Interests:** The authors have declared that no competing interests exist.